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On Testing the Law of Comparative Advantage

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Abstract

This paper reconsiders the law of comparative advantage (Deardorff, 1980, 1994) from an empirical point of view. I show that not only net exports valued at autarky prices but also those valued at free trade prices are needed to test the law of comparative advantage when trade is unbalanced. This result brings into question the empirical success of Bernhofen and Brown (2004). I propose a more general test that is consistent with both balanced and unbalanced trade and find that the empirical validity of the law of comparative advantage may not be robust once trade imbalance is taken into account. (100 words)

Key words: Law of Comparative Advantage; Trade Imbalance
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1 Introduction

Since Deardorff (1980, 1994) developed the general validity of the law of comparative advantage, it has long been believed that his Theorem is difficult to test because of the lack of relevant data. But the recent insightful paper by Bernhofen and Brown (2004) seemed to overcome this difficulty, focusing on the historical data of Japan's opening up at the end of the 1850s. In Japan, the Tokugawa government had prohibited all international trade and contracts in 1641 except at Dejima, a tiny island off Nagasaki where Dutch and Chinese merchants were allowed to trade.[1] Only a negligibly small amount of trade was conducted, and thus Japan was virtually in autarky for more than 200 years. In 1859, following the visit of US Commodore Matthew Perry in 1853, the Tokugawa government decided to open the Japanese economy. Accordingly, the shift from autarky to free trade occurred rapidly. It was in this context that Bernhofen and Brown (2004) tested the validity of Deardorff's Theorem, using price data for 1851-53 before the opening up (i.e., autarky) and trade data for 1868-75 just after the opening up (i.e., free trade). Their results strongly support the law of comparative advantage.

It is important to note that one of the underlying key assumptions in Deardorff's Theorem is balanced trade, a condition that has been commonly assumed in some of the empirical work in testing trade theory. However, since trade balance does not necessarily hold realistically, careful attention to the issue of trade balance is needed in empirically testing the trade theory. Thus, for example, Leamer (1980) pointed out that the Leontief paradox rested on the assumption of balanced trade. Although Bernhofen and Brown (2004) is the only empirical study that has attempted directly to test Deardorff's Theorem, it is worth analyzing how the balanced trade assumption affects their results.

In what follows, I reconsider Deardorff's Theorem of the law of comparative advantage from an empirical point of view. I show that not only net exports valued at *autarky prices* but also

[1] The trade of Japan in the Edo period (under the Tokugawa government for 1603-1867) and the following opening up in the Meiji period (1868-1912) are well documented in Ito (1992, pp. 8-12) and Bernhofen and Brown (2005).

those valued at *free trade prices* are needed to test the law of comparative advantage. Besides, the test will be asymmetric between the case of a trade surplus and the case of a trade deficit. The results imply that the empirical success of the test of comparative advantage by Bernhofen and Brown (2004) might simply rest on the existence of trade imbalance. I thus propose a more general test that is consistent with both balanced and unbalanced trade. Section 3 applies the test to Japan and presents the results.

2 Trade Imbalance and the Law of Comparative Advantage

Deardorff (1980) derived a theorem for the law of comparative advantage when trade is balanced. A simplified version of this theorem is as follows. Consider a world of M countries ($i = 1, ..., M$) and N goods ($j = 1, ..., N$). To simplify the analysis, I focus on two extreme cases: autarky and free trade. Let Q_i^a and Q_i^f be the vectors of goods produced in country i in autarky and free trade, respectively. Let p_i^a and p_i^f be the corresponding vectors of prices in autarky and free trade, respectively. Denote the vectors of consumption in autarky and free trade as C_i^a and C_i^f, respectively. Let $T_i (= Q_i^f - C_i^f)$ be a vector of net exports in free trade. Each country has its own production possibility set, F_i. Producers are assumed to behave competitively such that producers maximize the value of (net) production on a given production possibility set:

$$p_i^s Q_i^s \geq p_i^s Q_i \quad \text{for all } Q_i \in F_i \quad (s = a, f), \tag{1}$$

where, throughout the paper, all products of vectors represent inner products. Assume that aggregated consumer preferences follow the weak axiom of revealed preference:

$$p_i^a C_i^a \geq p_i^a C_i^f \Rightarrow p_i^f C_i^a > p_i^f C_i^f. \tag{2}$$

Finally, assume that trade is balanced:

$$p_t^f T = 0. \tag{3}$$

Given these assumptions, the following theorem is derived (as in Deardorff (1980), I omit the country subscript in what follows to focus on a single country).

Theorem (Deardorff, 1980)

Net exports valued at autarky prices is equal to or less than zero: $p^a T \leq 0$.

Proof: See Deardorff (1980).

Combining this theorem with (3), we have

$$(p^a - p^f)T \leq 0. \tag{4}$$

This Theorem thus states the "relative-autarky-price" measures of comparative advantage: a country is more likely to export good j (i.e., $T_j > 0$) if the autarky prices are lower than the free trade prices (i.e., $p_j^a - p_j^f \leq 0$) and import good j (i.e., $T_j < 0$) if the autarky prices are higher than the free trade prices (i.e., $p_j^a - p_j^f \geq 0$).

Assume now that each country has homothetic preferences.[2] When trade is not balanced, the following proposition can be derived.

Proposition (Deardorff, 1994)

Under the assumption of the Theorem as well as homothetic preferences, but without balanced trade, the net exports valued at the difference between autarky and free trade prices are less than or equal to zero: $(p^a - p^f)T \leq 0$.

Proof: See Deardorff (1994).[3]

[2]For the importance of the homothetic preferences assumption, see Deardorff (1994).

[3]The original Deardorff's Proposition does not have equality. However, whether the Proposition includes equality or not simply depends upon whether one includes the case of $p^a T = p^f T$. Since the original Theorem does not exclude the case of $p^a T = p^f T = 0$, I use the version of Deardorff's Proposition with equality.

The implication of the Theorem and the Proposition is twofold. First, we need the autarky price vector (p^a), the net trade vector in free trade (T), and the free trade price vector (p^f) in order to test the validity of the law of comparative advantage correctly. Equivalently, we need the inner products p^aT and p^fT. The appropriate test of comparative advantage is not $p^aT \leq 0$ but $(p^a - p^f)T \leq 0$. Second, and therefore, the test of $p^aT \leq 0$ does not necessarily test the law of comparative advantage.

The relationship between p^aT and p^fT is illustrated in Figure 1. The horizontal axis indicates p^fT while the vertical axis indicates p^aT. The 45-degree line indicates $p^aT = p^fT$. Therefore, the law of comparative advantage (i.e., $(p^a - p^f)T \leq 0$) holds in the shaded areas (i.e., areas B, C, and D), which corresponds to Deardorff's (1994) Proposition. When $p^fT = 0$ and $p^aT \leq 0$, Deardorff's (1980) Theorem holds. The law of comparative advantage does not hold in non-shaded areas. Note that $p^aT \leq 0$ includes the areas A, B, and C. If there is a trade surplus, the law of comparative advantage could hold when $p^aT > 0$ because $(p^a - p^f)T \leq 0$ covers not only area C but also area D. Similarly, if the trade balance is in deficit, the law of comparative advantage does not necessarily hold when $p^aT \leq 0$ because area A is in $(p^a - p^f)T > 0$.

=== Figure 1 ===

To clarify the message in Figure 1, suppose that one uses $p^aT \leq 0$ to test the law of comparative advantage. The larger the trade deficit becomes, the more likely it is to mistakenly accept the law of comparative advantage because area A does not support the validity of the law of comparative advantage. Similarly, the larger the trade surplus becomes, the more likely it is to reject the validity because area D is not included in $p^aT \leq 0$.

Figure 1 also suggests that there is a conceptual misunderstanding about the law of comparative advantage in Bernhofen and Brown (2004) in which used $p^aT \leq 0$ rather than $(p^a - p^f)T \leq 0$ in testing the law of comparative advantage. This means that their study tested whether the inner product is located in either areas A, B, or C rather than in areas B, C, or D. However, the law

of comparative advantage should be defined by the difference between autarky and free trade prices, not by the autarky prices only. More specifically, using their vector notation, $\mathbf{p}^a\mathbf{T} < 0 \Leftrightarrow (\mathbf{p}^a - \mathbf{p}^f)\mathbf{T} < 0$ iff $\mathbf{p}^f\mathbf{T} = 0$. On the other hand, if $\mathbf{p}^f\mathbf{T} < 0$, $\mathbf{p}^a\mathbf{T} < 0 \not\Rightarrow (\mathbf{p}^a - \mathbf{p}^f)\mathbf{T} < 0$. Because Japan's trade was not balanced throughout their sample period, the test of the law of comparative advantage by Bernhofen and Brown (2004) is not correct and, therefore, their results may not be robust. In order to conduct a correct test, we need the inner products p^fT as well as p^aT.

3 Empirical Implementation

3.1 Data

The previous section suggests that one needs net exports valued at autarky prices (p^aT) and those valued at free trade prices (p^fT) in order to test the law of comparative advantage correctly. Net exports valued at autarky prices are from Table 2 in Bernhofen and Brown (2004). They obtained autarky prices from various sources, which cover about 95 percent of exports and two-thirds of imports. They also estimated the autarky prices for the remaining commodities.

According to Bernhofen and Brown (2004, 2005), Japan was in autarky before 1859 and in free trade for 1868-75. This means that the inner product of free trade prices (p^f) and trade vector (T) during 1868-75 is equivalent to nominal net exports (p^fT) in that period. Net exports data for 1868-75 are obtained from Sugiyama (1998, p. 46, Table 3-4), which correspond to the data in Figure 3 in Bernhofen and Brown (2004).[4]

Note that the currency denominations of these sources are different each other: Ryō and Yen. Ryō is a currency in the Edo period. In 1871, the Meiji Government introduced a new currency, the Yen. Also, in the early Meiji period, both gold based Yen and silver based Yen were used.

[4] According to Sugiyama (1988, p. 45), two sources of trade statistics are available for this period. One is British consular reports after 1859 and the other is official Japanese statistics after 1868. Sugiyama (1988) compiled these trade statistics, adjusting the unit to Yen (silver) throughout the period. For more detail, see Sugiyama (1988, pp. 44-48).

While Bernhofen and Brown reported in Ryō (gold), Sugiyama (1988) reported in Yen (silver). Although the exchange rates among Ryō (gold) and Yen (gold) were 1 Ryō = 1 Yen = 1 US dollar (Yamamoto, 1994, p. 59 and p. 79), the exchange rates among Ryō (gold) and Yen (silver) were 0.773 Ryō = 1 Yen (silver) (Yamamoto, 1994, p. 79). I applied the latter exchange rate and converted from Yen (silver) to Ryō (gold) so that the net exports data are comparable to the data of Bernhofen and Brown.

It is also important to note that Japanese economy experienced rapid inflation at the end of the Edo period. As Bernhofen and Brown (2004, 2005) pointed out, the free trade should be compared to the autarky at one point in time. In order to remove the effects of inflation of export and import prices, counterfactual net exports (valued at 1851-53 prices) are estimated, deflating exports and imports using export and import price indexes in Shimbo (1978, p. 290, Table 5-10), respectively.

3.2 Results

Table 1 presents the results of the inner products p^aT and p^fT for 1868-75. The law of comparative advantage holds if $p^aT - p^fT \leq 0$. Figure 2 presents the actual relationship between p^aT and p^fT that corresponds to Figure 1. The results indicate that, although $p^aT \leq 0$ holds in all years, $p^aT - p^fT \leq 0$ does not necessarily hold. In two out of eight years, $p^aT - p^fT > 0$ is confirmed. This in turn means that the law of comparative advantage does not always hold in Japan once trade imbalance is taken into account.

=== Table 1 & Figure 2 ===

A simple t-test of $H_0 : p^aT - p^fT > 0$ is also conducted. The result indicates that the null hypothesis (H_0) is rejected at five percent significance level (p-value = 0.016). However, I also find that the test result is sensitive to whether the first or the last two sample years are included or not. If the first two years (1868 and 1869) are excluded, the null hypothesis can be rejected at

0.3 percent significance level. If, instead, the last two years (1874 and 1875) are excluded, the null hypothesis cannot be rejected at five percent significance level (and, in addition, $p^a T - p^f T$ is no longer significantly different from zero).

Bernhofen and Brown (2004) deserves credit for their insightful analysis that sheds light on the empirical test of the law of comparative advantage, combining theory with history. This paper shows, however, that not only net exports valued at *autarky prices* but also those valued at *free trade prices* are needed in order to test the law of comparative advantage correctly when trade is not balanced. The results suggest that the empirical validity of the law of comparative advantage may not be robust once trade imbalance is taken into account. The discussion of the empirical validity of Deardorff's Theorem thus awaits further research.

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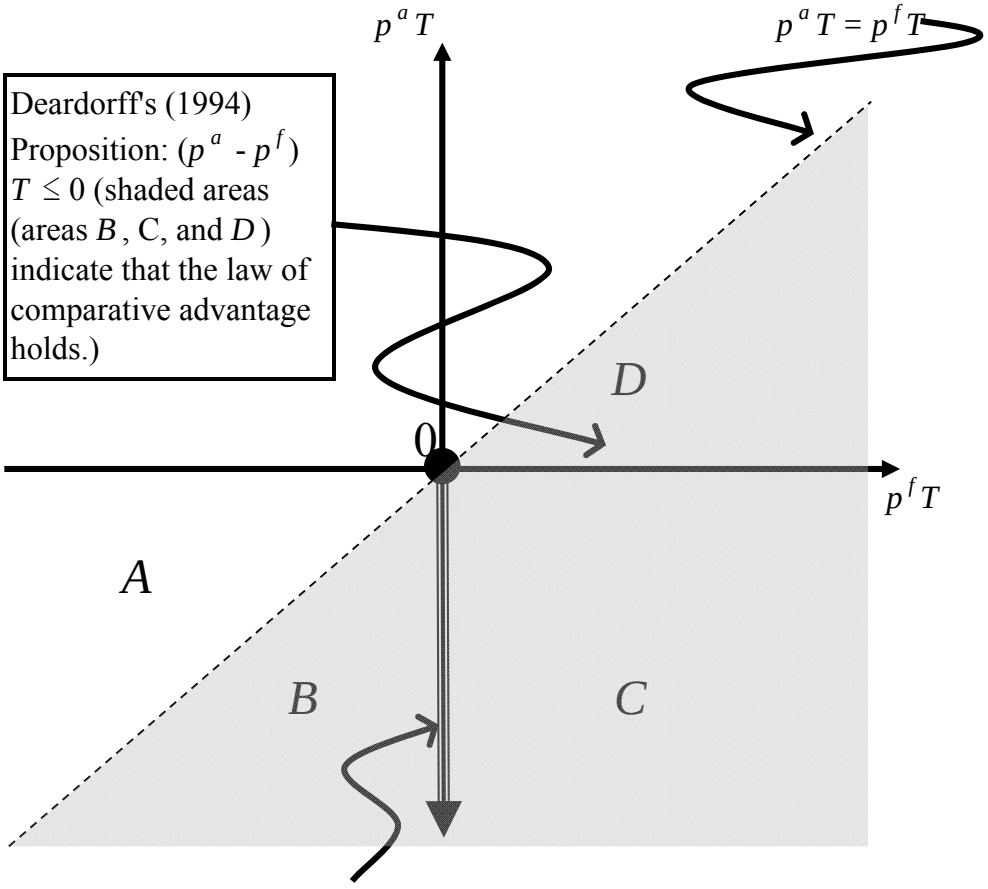
Figure 1. Relationship between $p^a T$ and $p^f T$



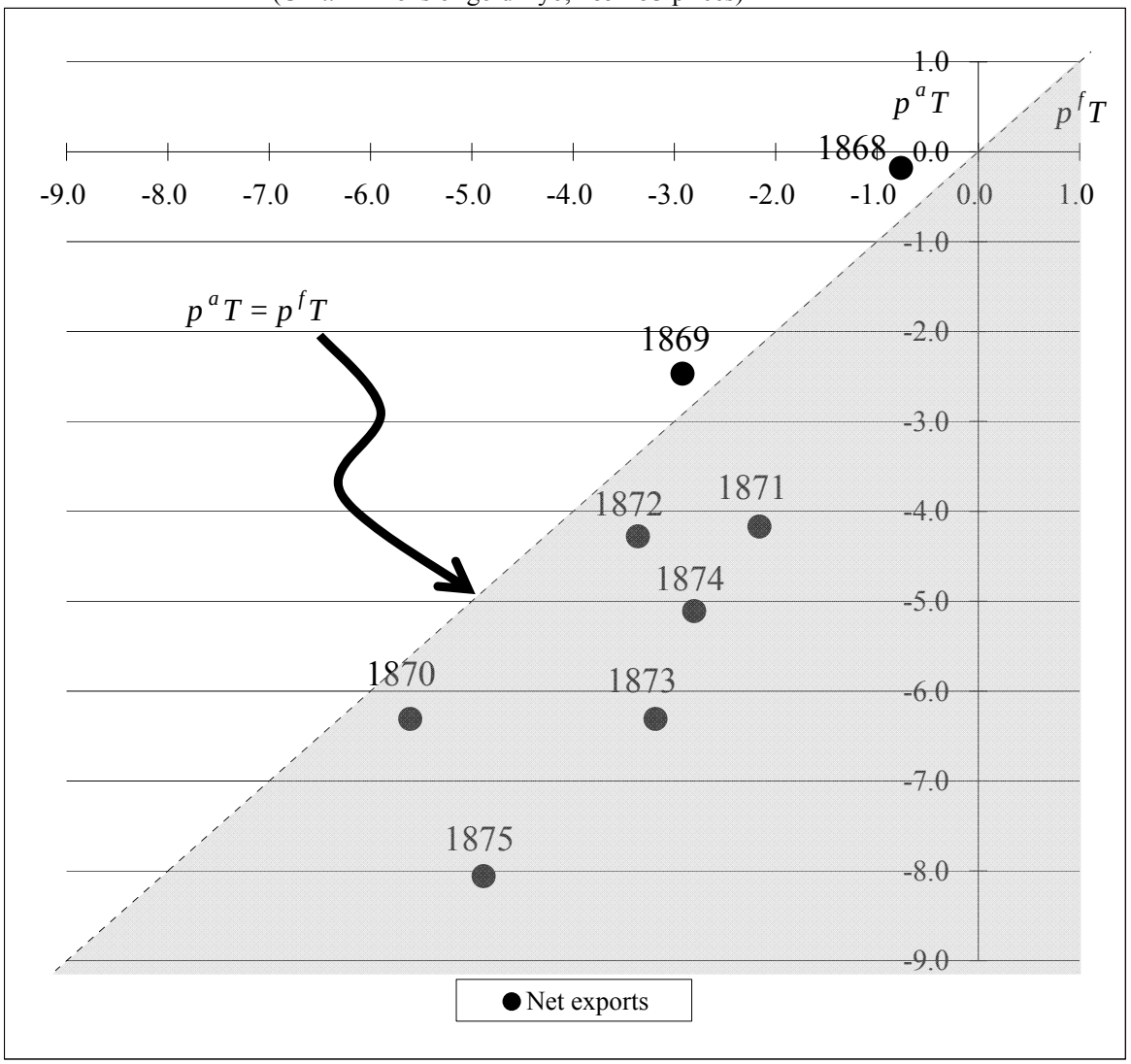
Deardorff's (1980) Theorem: $p^f T = 0 \;\; \& \;\; p^a T \leq 0$

Notes: 1) Shaded areas (areas B, C, and D) indicate that the law of comparative advantage (Deardorff's Proposition: $(p^a - p^f)T \leq 0$) holds. In non-shaded area, on the other hand, the law of comparative advantage does not hold.

2) The test of $p^a T \leq 0$ means whether or not net exports valued at autarky prices locate in either areas A, B, or C. In the case of a trade deficit, the test of $p^a T \leq 0$ does not necessarily test the law of comparative advantage because the law of comparative advantage does not hold when $p^f T < p^a T < 0$ (area A) even though $p^a T \leq 0$. Similarly, in the case of a trade surplus, the test of $p^a T \leq 0$ does not necessarily test the law of comparative advantage because the law of comparative advantage holds $0 < p^a T < p^f T$ (area D) even though $p^a T > 0$.

Figure 2. Actual Relationship between $p^a T$ and $p^f T$

(Unit: Millions of gold Ryō, 1851-53 prices)



Note: Shaded area indicates that the law of comparative advantage (Deardorff's Proposition: $(p^a - p^f)T \leq 0$) holds. In non-shaded area, on the other hand, the law of comparative advantage does not hold.

Source: $p^a T$ and $p^f T$ are net exports in Table 1.

Table 1. An Approximate Inner Product $p^a T - p^f T$ in Various Test Years

	(1)	(2)	(3) = (1) - (2)	(4)	(5)	(6)	(7)	(8) = (4) / (6)	(9) = (5) / (7)	(10) = (8) - (9)	(11) = (3) - (10)
	$p^a T$ (1851-53 prices, millions of gold Ryō)			$p^f T$ (current prices, millions of gold Ryō)		Price index (1851-53 = 1.00)		$p^f T$ (1851-53 prices, millions of gold Ryō)			$p^a T - p^f T$ (1851-53 prices, millions of gold Ryō)
	Bernhofen and Brown (2004)			Sugiyama (1988)		Shimbo (1978)		Sugiyama (1988), adjusted			
Year	Exports	Imports	Net exports	Exports	Imports	Exports	Imports	Exports	Imports	Net exports	
1868	4.16	4.32	-0.16	17.77	14.96	4.71	3.30	3.77	4.53	-0.76	0.60
1869	3.43	5.89	-2.46	9.98	16.74	4.99	3.40	2.00	4.92	-2.92	0.46
1870	4.11	10.43	-6.32	11.24	27.06	5.44	3.53	2.07	7.67	-5.61	-0.71
1871	5.23	9.41	-4.18	13.89	17.06	5.55	3.66	2.50	4.66	-2.16	-2.02
1872	5.14	9.42	-4.28	13.16	20.23	5.14	3.42	2.56	5.92	-3.36	-0.92
1873	4.15	10.46	-6.31	16.72	21.73	4.78	3.25	3.50	6.68	-3.19	-3.12
1874	5.19	10.31	-5.12	14.93	18.93	4.63	3.14	3.22	6.03	-2.80	-2.32
1875	4.90	12.96	-8.06	14.39	24.66	4.46	3.04	3.22	8.11	-4.88	-3.18

Notes: 1) $p^a T$ is from Bernhofen and Brown (2004, Table 2).

2) $p^f T$ is from Sugiyama (1988, p. 46, Table 3-4) and is the same data used in Bernhofen and Brown (2004, Figure 3), converted from Yen (silver) to Ryō (gold) by the exchange rate (0.773 Ryō (gold) = 1 Yen (silver)).

3) "Sugiyama (1988), adjusted" means that exports and imports are deflated by export and import price indexes, respectively, to obtain counterfactual 1851-53 prices. Price indexes are obtained from Shimbo (1978).

Sources: Shimbo (1978, p. 290, Table 5-10), Sugiyama (1988, p. 46, Table 3-4), and Bernhofen and Brown (2004, Table 2).